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1. **Your reference**

   MPS/8576

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2. **Patent application number**
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   0327961.9

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3. **Full name, address and postcode of the or of each applicant** *(underline all surnames)*

   Iain Norman Bridge
   21 Walton Gardens, Codsall,
   Staffordshire, WV8 1AH.

   Patents ADP number *(if you know it)*

   87650000 - 3 DEC 2003

   If the applicant is a corporate body, give the country/state of its incorporation

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4. **Title of the invention**

   Panel Structure

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5. **Name of your agent** *(if you have one)*

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   Swindell & Pearson

   48 Friar Gate
   Derby
   DE1 1GY

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   00001578001 ✓

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7. **Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute** (see note f)

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   No

   Answer YES if:
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Continuation sheets of this form	0
Description	11
Claim(s)	3
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Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent (Patents Form 7/77)	
Request for a preliminary examination and search (Patents Form 9/77)	1
Request for a substantive examination (Patents Form 10/77)	
Any other documents (please specify)	

11. I/We request the grant of a patent on the basis of this application. Swindell & Pearson

Signature(s) Swindell & Pearson Date 02/12/03

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom — Mr. M.P. Skinner - 01332 367051

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Panel Structure

The present invention relates to panel structures and their formation.

In accordance with the present invention, there is provided a panel structure comprising at least two sheets which are spaced apart and tied together by a plurality of tie means extending from one of the sheets to the other, the tie means being formed of substantially the same material as the sheets, and wherein the sheets and the tie means form an uninterrupted body of the material.

Preferably, an open void is defined between the sheets. Alternatively, the space between the sheets may be filled with a different material, such as a foam material.

The said material of the sheets and tie means may be a thermosetting or thermoplastic plastics material, polymer material, metal alloy, or paper board. The said material may incorporate reinforcing fibres.

The sheets are preferably generally planar and preferably generally parallel.

The tie means may each consist of material of one or more sheets, deformed out of the plane of the corresponding sheet and fused to material of the other sheet. Preferably material of both sheets is deformed from the respective plane to be fused with material of the other sheet at a position between the sheets. Preferably, the material of the sheets is fused midway between the sheets.

The material may be deformed by a process which includes the application of heat. The material may be deformed to form hollow projections

toward the other sheet. Alternatively, the material may be deformed to form solid projections toward the other sheet. The projections may be formed with pointed, rounded or flat peaks for fusion with corresponding peaks formed from the other sheet.

Preferably no more than one half of the area of the sheets is deformed to form tie means. The sheets are preferably substantially planar between areas of deformation. The sheets may be deformed only at points, being substantially undeformed therebetween.

The ties are preferably arranged across the sheets in a geometric lattice. The ties may be arranged to leave unobstructed straight voids extending within the plane of the panel structure, for receiving rigid elongate members.

Various embodiments of the present invention will now be described in more detail, by way of example only, and with reference to the accompanying drawings in which:

Fig. 1a is a perspective view of a panel structure in accordance with a first embodiment of the invention, shown partly cut away;

Fig. 1b is a section along the line B-B of Fig. 1a and Fig. 1c is an enlarged view of part of Fig. 1b;

Figs. 2a, 2b and 2c correspond with Figs. 1a, 1b and 1c respectively, illustrating a second embodiment;

Figs. 3a, 3b and 3c correspond with Figs. 1a, 1b and 1c respectively, illustrating a third embodiment;

Fig. 4 is a section through a fourth embodiment of panel structure;

Figs. 5a and 5b illustrate the panel faces of the first and fourth embodiments; and

Fig. 6, Figs. 7a and 7b illustrate various methods and arrangements for forming panel structures in accordance with the invention;

Fig. 8 is a perspective view illustrating a fifth embodiment;

Fig. 9 illustrates an intermediate step in the formation of the panel structure of Fig. 8;

Figs. 10a and 10b are sections along the lines A-A and B-B of Fig. 8, respectively; and

Figs. 11a and 11b illustrate further methods and arrangements for forming panel structures in accordance with the invention.

Fig. 1 shows a panel structure 10 formed from two sheets 12. The sheets 12 are spaced apart and tied together at various positions by tie means indicated generally by the numeral 14. The ties 14 extend from one of the sheets 12 to the other.

As will be described, the ties 14 are formed of substantially the same material as the sheets 12 and in such a way that the sheets 12 and the tie means 14 form an uninterrupted body of material.

Each sheet 12 is generally planar except in the region of each tie 14. At these positions, the material of the sheet 12 is deformed from the plane of

the sheet 12, in a manner to be described, to form a projection 16 toward the other sheet 12. The projections 16 are hollow. The projections 16 meet corresponding projections from the other sheet 12 at a plane indicated in Figs. 1b and 1c by a broken line 17. A solid line is not used because the material of the projections 16 is fused at this location, as part of the forming process, in order to form a single uninterrupted body of material across the sheets 12 and through the ties 14.

The sheets 12 may be formed of a thermosetting or thermoplastic plastics material, a polymer material, a metal alloy, or a paper board etc. for example. The material may optionally incorporate reinforcing fibres indicated at 18.

It can be seen from Figs. 1a to 1c that in this embodiment, the projections 16 have generally flat peaks prior to fusion, so that fusion takes place across the whole of the area of the peak.

A space 20 is defined between the sheets 12 and may be left unfilled, as an open void (as shown toward the left of Fig. 1b) or may be partly or wholly filled, such as with a foam material 22 (as shown toward the right of Fig. 1b). The foam material is not necessarily required for the structural performance of the panel 10, but may be incorporated for other reasons, such as thermal or sound insulation.

A second embodiment is shown in Figs. 2a to 2c. Features corresponding with those of Fig. 1 are given corresponding reference numerals, suffixed a.

In the second embodiment, the panel 10a again comprises two sheets 12a connected by tie means 14a formed by projections 16a. The difference between the first and second embodiments relates to the shape of the

projections 16a. In the second embodiment, the projections 16a are conical, with pointed peaks, so that the area of intimate contact and fusion between the projections 16a is relatively small in the second embodiment, in comparison with the area provided by the flat peaks of the projections 16.

Fusion of the peaks results in a single uninterrupted body of material across the sheets 12a and through the ties 14a.

Again, the sheets 12a are preferably a thermosetting or thermoplastic plastics material, a polymer material, a metal alloy or a paper board etc., and may incorporate reinforcing fibres (not shown in Fig. 2). The space 20a may be left as an open void, or filled with foam (not shown in Fig. 2).

Figs. 3a to 3c show a third embodiment of panel structure 10b. Again, like reference numerals are used for corresponding features, with the suffix b.

In this third embodiment, the sheets 12b are tied by tie means 14b in the form of conical, pointed and solid projections 16b. Thus, the main difference between the third embodiment and the first two embodiments is that the projections 16b are solid rather than hollow. Thermosetting or thermoplastic plastics material, a polymer material, a metal alloy or a paper board etc. is again preferably used, and may optionally incorporate reinforcing fibres. The space 20b may be an open void or foam-filled.

Fusion of the peaks results in a single uninterrupted body of material across the sheets 12b and through the ties 14b.

A fourth embodiment of panel structure 10c is illustrated in section in Fig. 4, again using like numerals and the suffix c.

In the panel 10c, the sheets 12c are planar across almost their entire area. The ties 14c are in the form of thin spindles 16c of material, forming spaced columns extending substantially perpendicular to the sheets 12c. Again, the sheets 12c and ties 14c are preferably formed of thermosetting or thermoplastic plastics material, a polymer material, a metal alloy, or a paper board etc. with optional reinforcing fibres. The sheets 12c and spindles 16c together form a single uninterrupted body of material.

Figs. 5a and 5b show the outer faces of the first and fourth embodiments. In Fig. 5a, the hollow nature of the projections 16 results in visible concavities 26 at each projection location 28. The projection locations are arranged at the interstices of a geometric lattice, illustrated in this example as a square lattice 30, indicated by broken lines. The square size of the lattice 30, in comparison with the size of the concavities 26, results in the projections 16 being sufficiently widely spaced to leave unobstructed straight voids extending within the plane of the panel 10, between the projections 16. This allows a rigid elongate member, such as a pipe, service duct, reinforcing bar or other member to be housed within the space 20, as illustrated at 32 in Fig. 1b.

In the fourth embodiment, illustrated in Fig. 5b, the projections 16c are again arranged on a square lattice 30. However, the narrow and solid nature of the spindles 16c results in the exposed face of the panel 10c being wholly or virtually unaltered from a planar surface, even at the projection locations 28. For clarity, the locations of the spindles 16c are illustrated in Fig. 5b by means of small circles. It can again be seen, in common with the first embodiment, that the spacing of the spindles 16c leaves unobstructed straight voids in various directions through the plane of the panel 10c, so that members 32 can again be received, as described above.

It can readily be seen from both Figs. 5a and 5b that the area between the projection locations 28, represents significantly more than one half of the total area of the sheets 12. That is to say, no more than one half of the area of the sheets 12 is deformed to form ties 14. In Fig. 5a, there is deformation to form the concavities 26, but these are sufficiently small to leave half, or more than one half of the area of the sheets undeformed, between projection locations 28. In the arrangement of Fig. 5b, as has been described, the columns 24 are sufficiently small that the outer face of the panel 10c is virtually undeformed by the formation of the spindles 16c.

Fig. 6 illustrates a first method for forming a panel structure in accordance with the invention. This first method is particularly appropriate for use with the first embodiment, but may also be used with the second embodiment. The method will be described in relation to the first embodiment.

The sheets 12 are first provided, preformed to have the projections 16. The sheets 12 are oriented so that the respective projections 16 each project towards the other sheet, and the sheets 12 are then brought together so that the peaks of the projections 16 come together in intimate contact. Heat is then applied to the peaks, for example by introducing sources of heat into the concavities 26, at the positions indicated by the arrows 34, resulting in the material in the region of the projection peaks being heated and softened. This allows the material of the two sheets to be fused by melting, so that the material of the two sheets blends into a single whole. The result is illustrated particularly in Fig. 1c. It is this process of creating fusion between the sheets which makes it appropriate to use a broken line to indicate the two projections 16 in Fig. 1c, rather than a solid line. In practice, after the fusion has occurred, it ceases to be possible to identify the precise location of the boundary between the two projections which have fused. A single body of

material has been formed from the fusion of the two bodies which were initially separate and distinct.

Figs. 7a and 7b illustrate a second method which may be used to form a panel structure.

In this method, two planar sheets of material 12 are brought together in intimate contact, both being planar at this stage. Heating is then applied at the projection locations, as indicated by arrows 36. This causes localised heating of the thermosetting or thermoplastic material of the sheets 12, so that the material of the two sheets fuses together at these locations.

After fusion has begun, but before the material has fully cooled, and thus while the material remains plastic, the sheets 12 are moved apart (Fig. 7b), causing ties 14 to begin to form by material being stretched between the sheets 12. The sheets 12 may be moved apart either by suction from outside the panel or by blowing air or other fluid between the sheets 12, forcing them apart.

As the separation continues, the ties 14 continue to form until their final form is reached. The sheets 12 are then maintained in this position until the material fully cools.

The process just described is particularly appropriate for forming the fourth embodiment, using localised heating to form columns connecting the sheets. The process can be modified when used to form the first and second embodiments, in two principal respects. First, secondary regions of heating, indicated by arrows 38, are applied as rings of heating around each projection location. The secondary heating at 38 is less than at the projection location, either being at a lower temperature, or for a shorter duration, so that the material around the ring is not softened sufficiently to fuse with the other sheet

12. Consequently, whereas the material at the projection location 28 fuses, material in the surrounding ring is merely softened. Consequently, as the sheets 12 are moved apart, the softened material of the rings 38 can stretch to form side walls 40 of the projections 16, 16A, but without fusing to material of the other sheet 12. This helps form projections of the type shown in the first and second embodiments, and may be further assisted by forcing the sheets 12 against a shaped mould tool or other former, as they move apart.

A fifth embodiment is illustrated in Fig. 8 and has a tie geometry which is more complex than in the embodiments described above, as can best be described by first explaining the process of formation of the panel structure 10d. This begins with three planar sheets 12d, 12e, placed together as shown in Fig. 9. Heating is applied at 48 from both faces of this three layer assembly. The heating locations on both faces are arrayed in a geometric lattice, such as a square lattice, but the two lattices are offset with respect to each other so that at each heating location, heating takes place from one face or the other, but not both. Consequently, the middle sheet 12e becomes fused at each heating position, either to the sheet 12d to one side or to the other, but not to both. When the sheets 12d are moved apart (Fig. 10a), this stretches the sheet 12e into a zig-zag form.

The geometry of the heating locations and their sizes can readily be modified to change the resulting geometry of the ties 14d. For example, larger areas of heating could be effected from one face than from the other, or other changes could be made to create asymmetry in the final arrangement of ties 14d.

Fig. 11 illustrates a technique in which the methods of Figs. 6 or 7 may be implemented as a continuous process. Sheets 12 are fed continuously from the left hand side of Fig. 11a toward the nip of rollers 42. The surface of one of the rollers 42 is illustrated on an enlarged scale in Fig. 11b. The roller

42 has lines of suction apertures 44 and lines of heating elements 46. Consequently, as the sheets 12 pass through the nip of the rollers 42, regions corresponding with the projection locations 28 are heated by the heating elements 46. As the sheets 12 leave the nip, suction though the apertures 44 tends to hold the sheets 12 against the rollers, so that the sheets 12 are held or pulled apart. Consequently, the locations 28 which have been heated and fused are then stretched to form ties, in the manner described in relation to Fig. 7b. Alternatively, the rollers 42 may have more complex surface form, to accommodate sheets 12 which are preformed with projections 16 (for example by means of a previous step involving heated forming rollers), so that heat is applied at the peaks of the projections 16 (as illustrated in Fig. 6a) but without suction thereafter being required.

In all of the methods described above, the use of fusion between two panels of thermoplastic or thermosetting material allows a single, uninterrupted body of material to be formed, effectively without boundaries and thus, without structural weaknesses which boundaries create. The result is a panel structure in which two spaced apart panels are tied together, so that they cannot move in shear. That is, they cannot move within their plane, relative to the other sheet, subject to the strength and disposition of the ties. This shear movement would be required for any bending of the panel structure and thus, resistance to bending is created by this resistance to shear movement. The result is a structure in which the strength, for example strength against impact, is provided ~~primarily~~ by the sheets (which may be formed as thickly as is appropriate), but in which bending resistance is provided primarily by the manner of tying them together. The presence of a void within the structure allows a rigid but lightweight structure to be created.

A rigid, lightweight panel structure of the type described can be used advantageously in the formation of caravans, motor homes, boats, buildings (especially temporary or portable buildings), for transportation packaging and

platforms, for vehicle chassis, for window shutters, for concrete formwork, for footwear soles, and in many other ways. In many of these, it is advantageous that the undeformed outer surface of the sheets 12 forms at least 50% of the total surface area, so that additional panels or sheet material, particularly covering applied for cosmetic reasons, can be applied with a good visual finish. Thus, the panel structure may be used as the wall of a caravan or mobile home, and covered with a conventional wallpaper, without the form of the panel structure becoming apparent, particularly if the fourth embodiment is used.

Many variations and modifications may be made to the structures described above, without departing from the scope of the invention. In particular, a range of different materials could be used. Also, different means of achieving continuity in the ties may be used, such as exothermic fusion for thermosetting polymers or resin impregnated paper board. Dimensions and relative dimensions could be changed from those described.

The description has referred to two parallel sheets, tied together, but could be implemented with a greater number of sheets, or with sheets which are not precisely parallel.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

1. A panel structure comprising at least two sheets which are spaced apart and tied together by a plurality of tie means extending from one of the sheets to the other, the tie means being formed of substantially the same material as the sheets, and wherein the sheets and the tie means form an uninterrupted body of the material.

2. A panel structure according to claim 1, wherein an open void is defined between the sheets.

3. A panel structure according to claim 1, wherein the space between the sheets is filled with a different material.

4. A panel structure according to claim 3, wherein the space is filled with a foam material.

5. A panel structure according to any preceding claim, wherein the said material of the sheets and tie means is a thermosetting or thermoplastic plastics material, polymer material, metal alloy or paper board.

6. A panel structure according to any preceding claim, wherein the said material incorporates reinforcing fibres.

7. A panel structure according to any preceding claim, wherein the sheets are generally planar.

8. A panel structure according to claim 7, wherein the sheets are generally parallel.

9. A panel structure according to any preceding claim, wherein the tie means each consist of material of one or more sheets, deformed out of the plane of the corresponding sheet and fused to material of the other sheet.

10. A panel structure according to claim 9, wherein material of both sheets is deformed from the respective plane to be fused with material of the other sheet at a position between the sheets.

11. A panel structure according to claim 10, wherein the material of the sheets is fused midway between the sheets.

12. A panel structure according to claim 9, 10 or 11, wherein the material is deformed by a process which includes the application of heat.

13. A panel structure according to any of claims 9 to 12, wherein the material is deformed to form hollow projections toward the other sheet.

14. A panel structure according to any of claims 9 to 12, wherein the material is deformed to form solid projections toward the other sheet.

15. A panel structure according to any of claims 9 to 14, wherein the projections are formed with pointed, rounded or flat peaks for fusion with corresponding peaks formed from the other sheet.

16. A panel structure according to any of claims 9 to 15, wherein no more than one half of the area of the sheets is deformed to form tie means.

17. A panel structure according to claim 16, wherein the sheets are substantially planar between areas of deformation.

18. A panel structure according to claim 16 or 17, wherein the sheets are deformed only at points, being substantially undeformed therebetween.

19. A panel structure according to any preceding claim, wherein the ties are arranged across the sheets in a geometric lattice.

20. A panel structure according to claim 19, wherein the ties are arranged to leave unobstructed straight voids extending within the plane of the panel structure, for receiving rigid elongate members.

21. A panel structure substantially as described above, with reference to the accompanying drawings.

22. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.

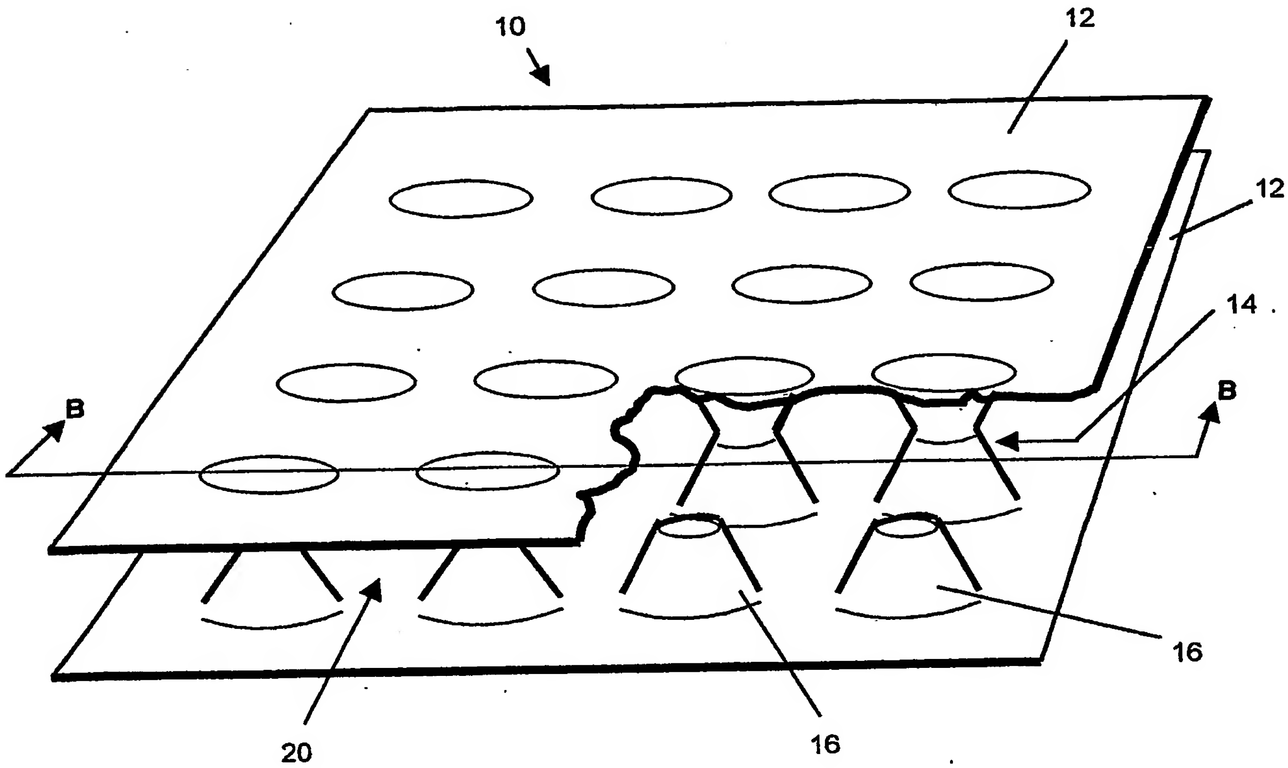

FIGURE 1a

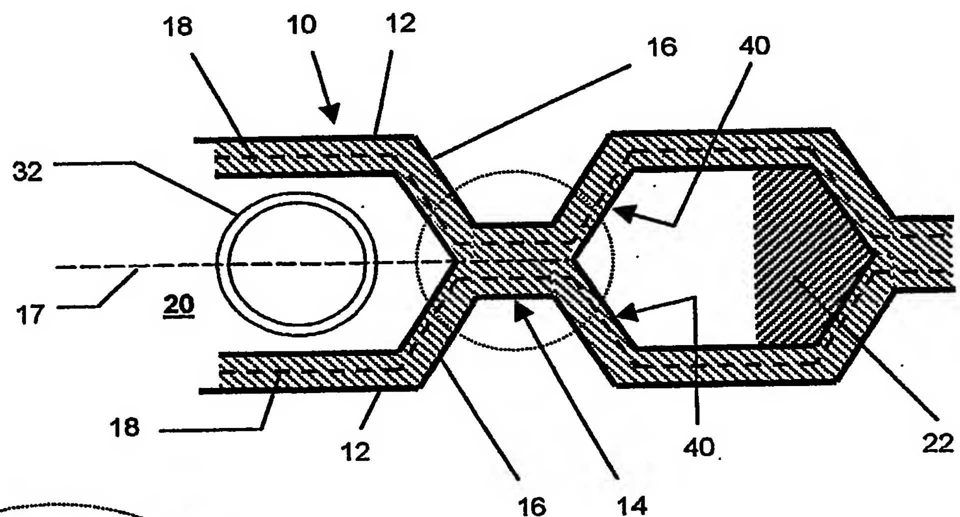

FIGURE 1b

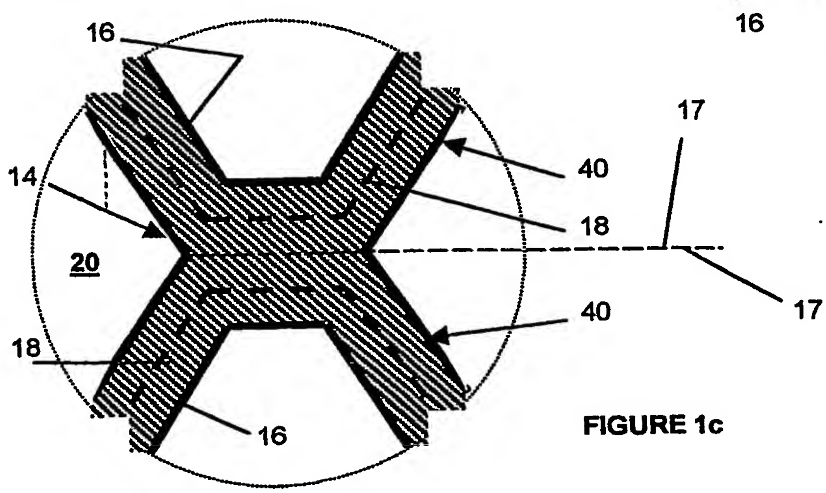

FIGURE 1c

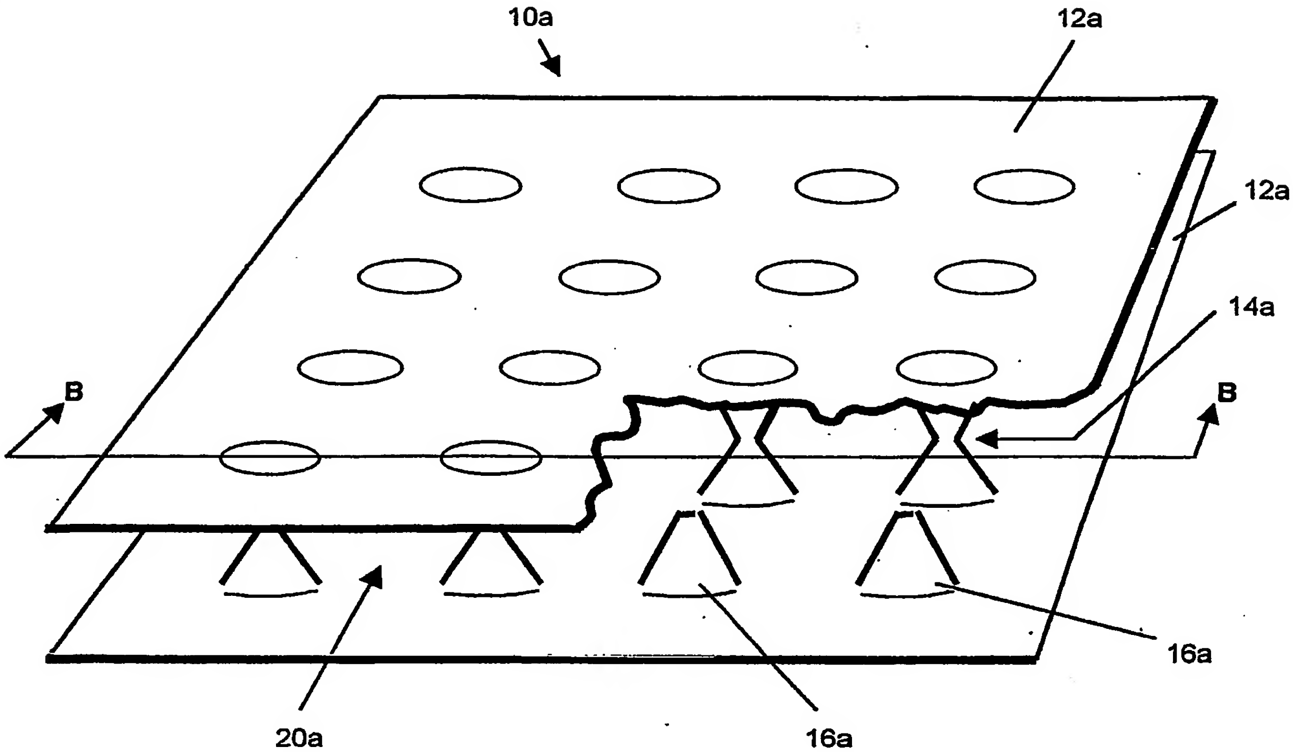

FIGURE 2a

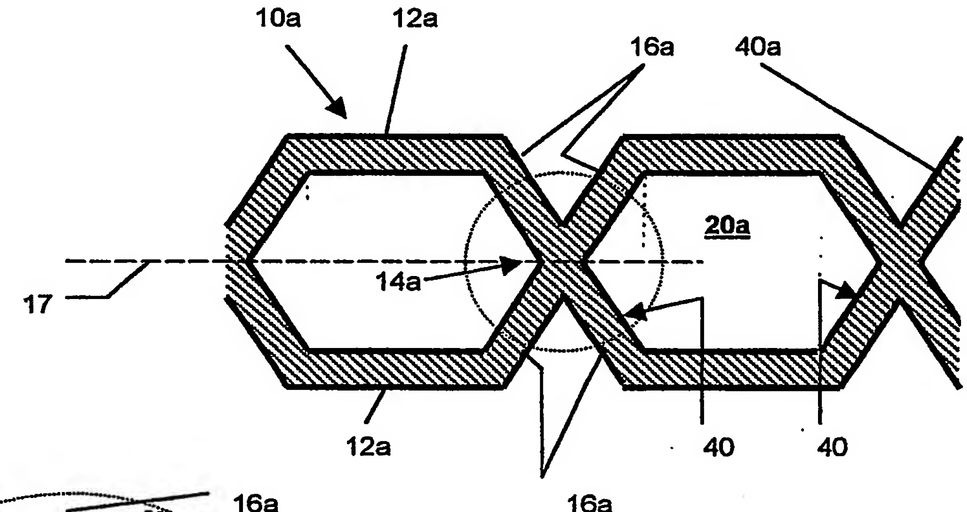

FIGURE 2b

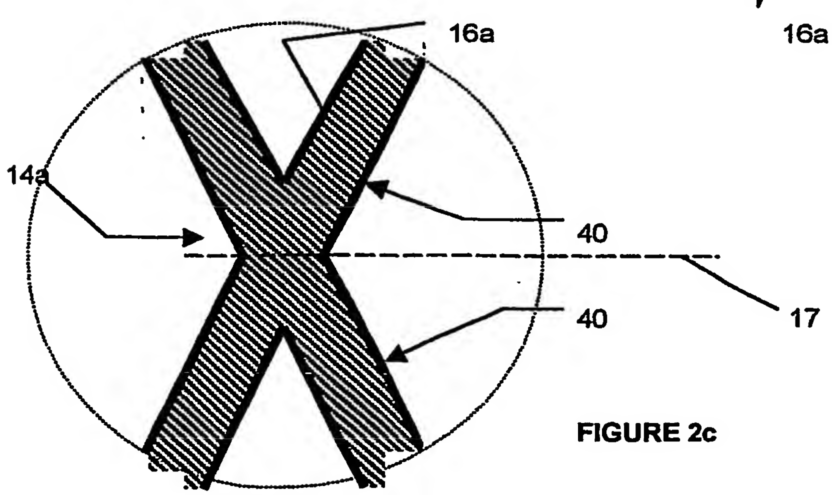

FIGURE 2c

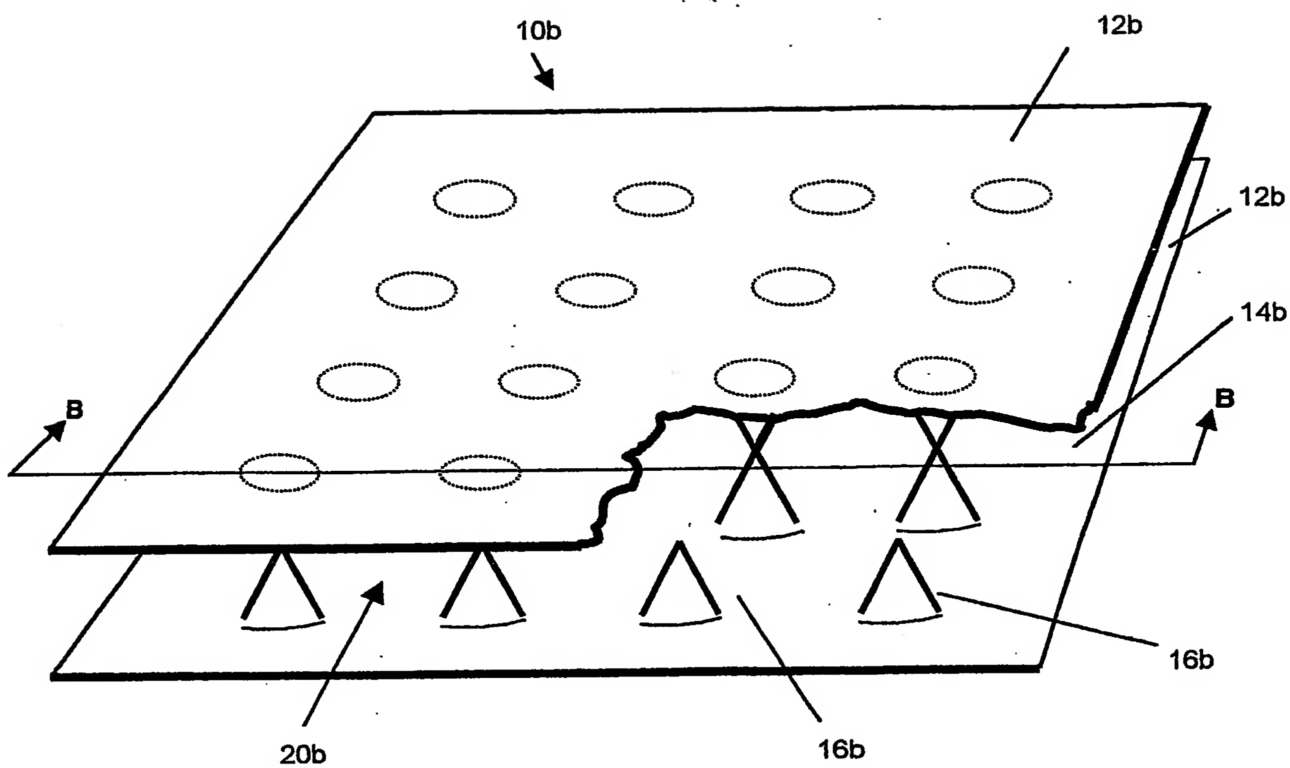

FIGURE 3a

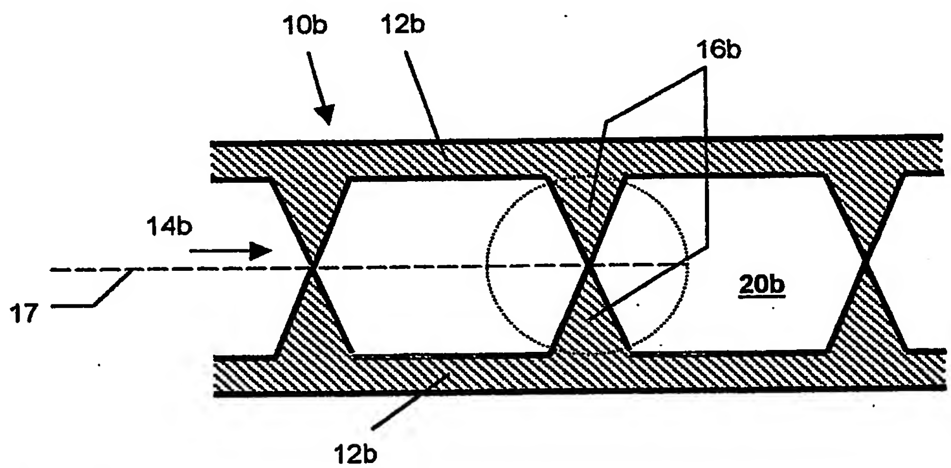

FIGURE 3b

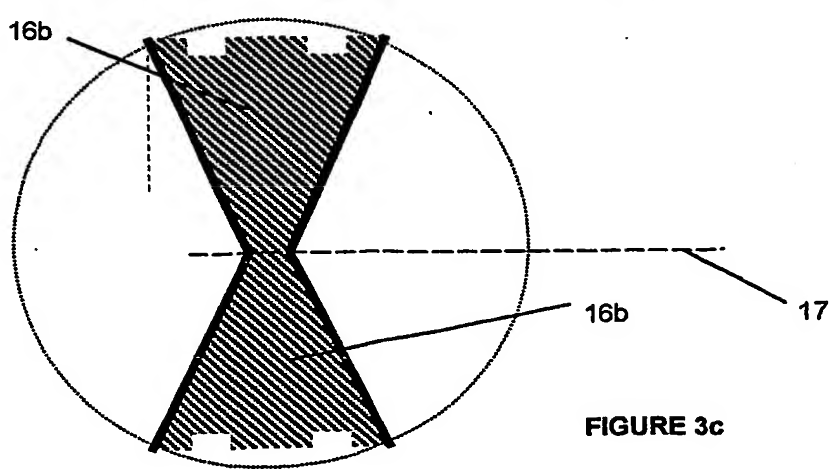

FIGURE 3c

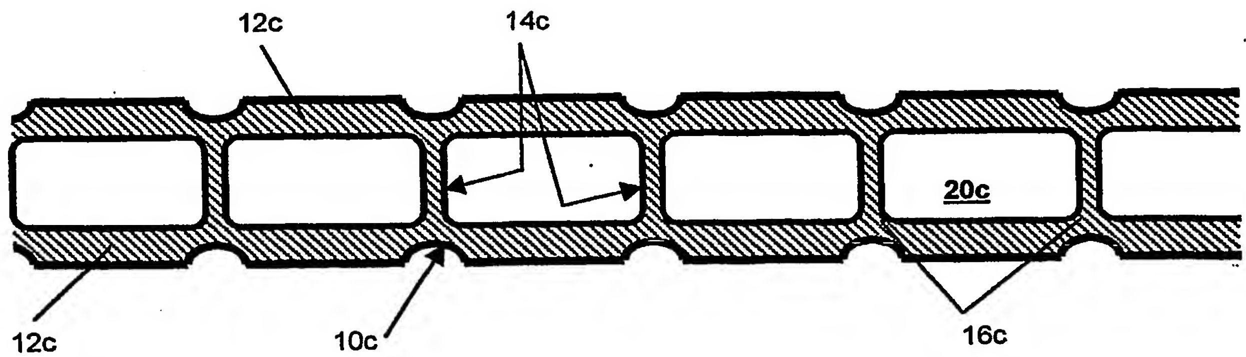

Figure 4

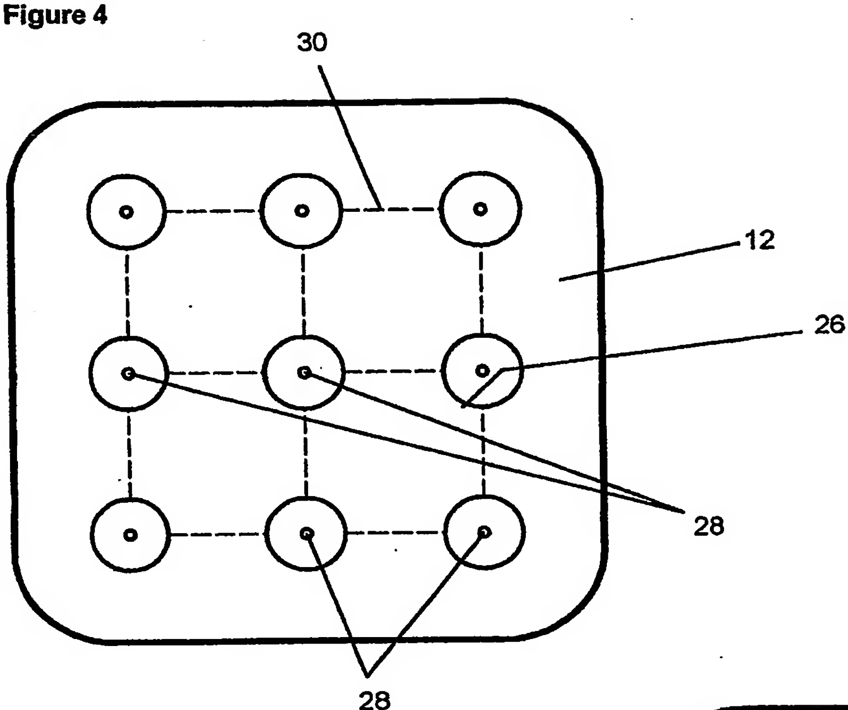

Figure 5a

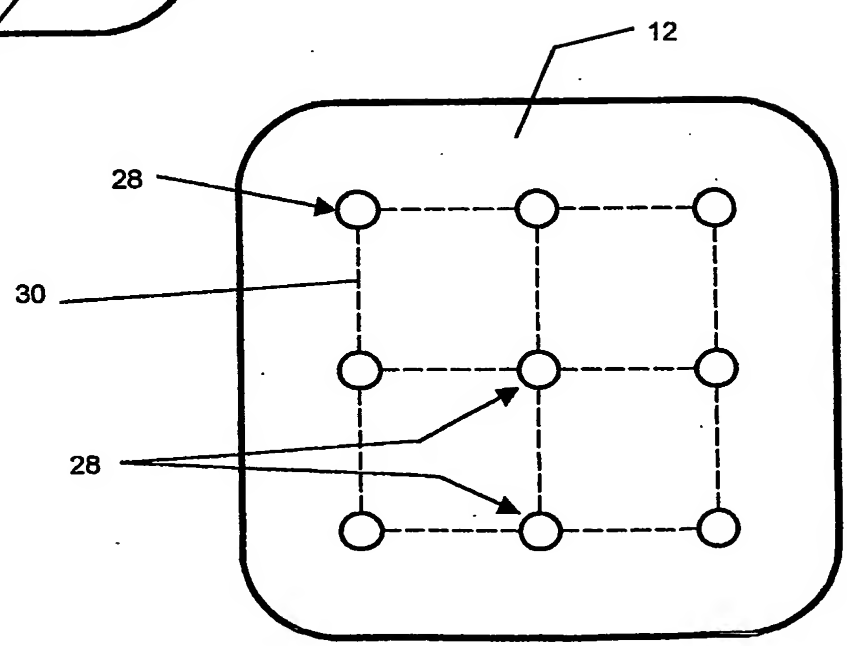

Figure 5b

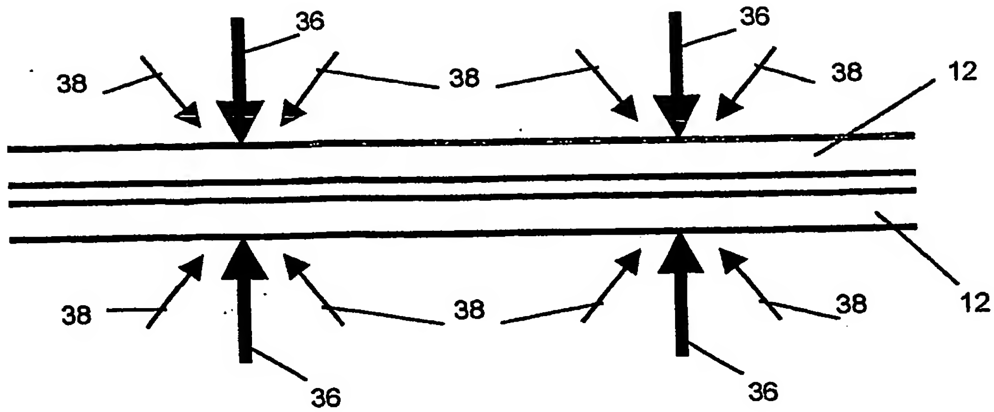

Figure 7a

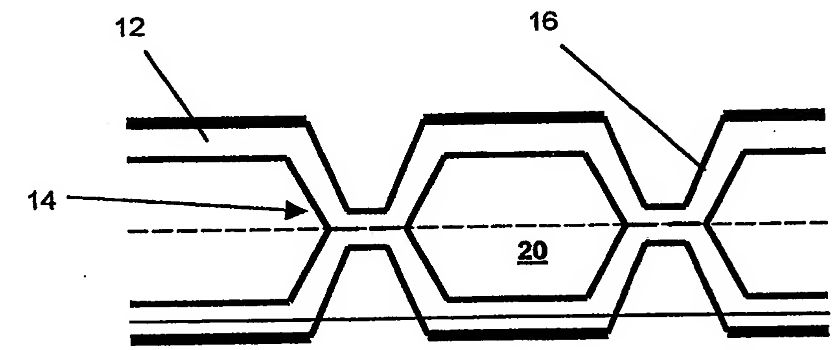

Figure 7b

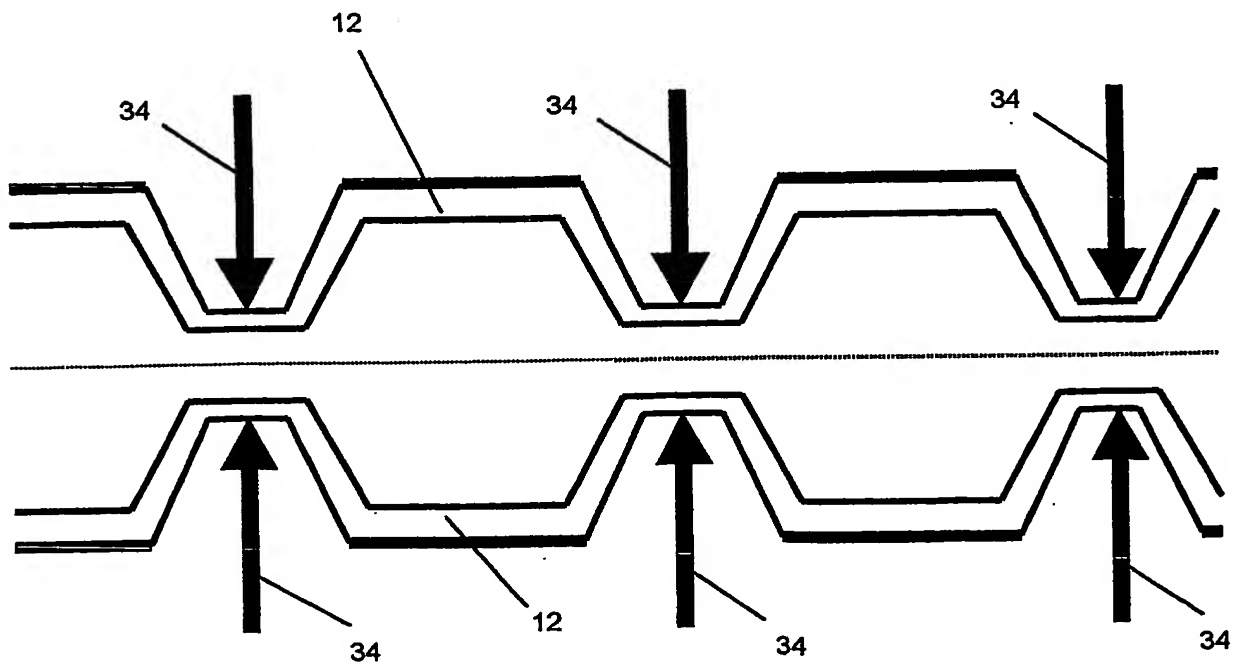

Figure 6

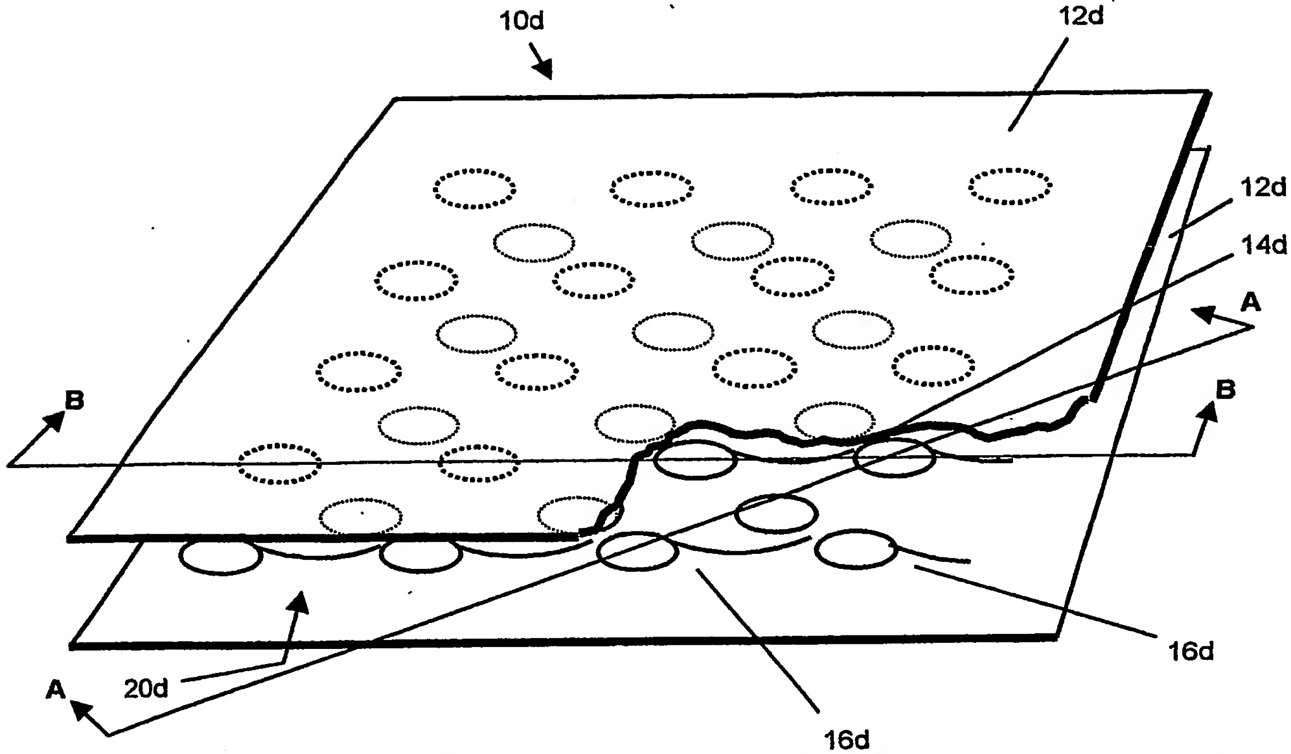

FIGURE 8

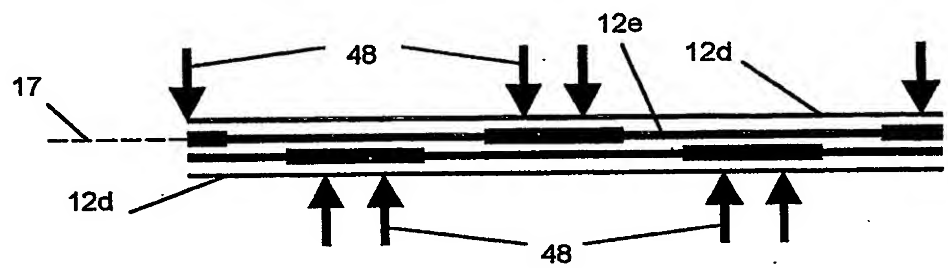

FIGURE 9

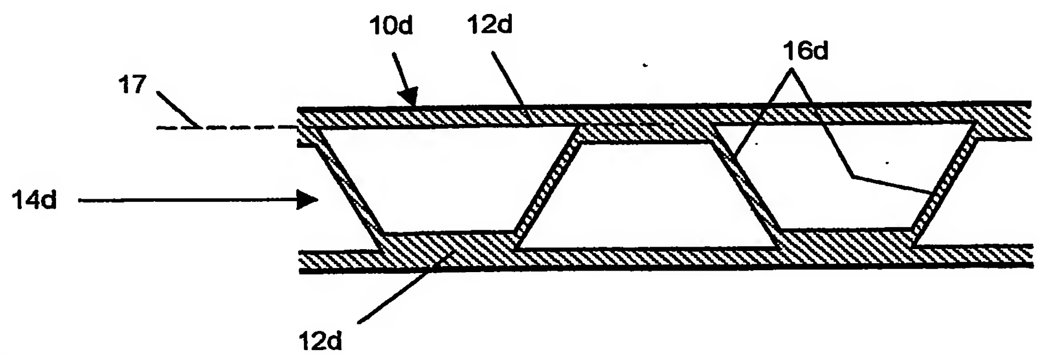

FIGURE 10a

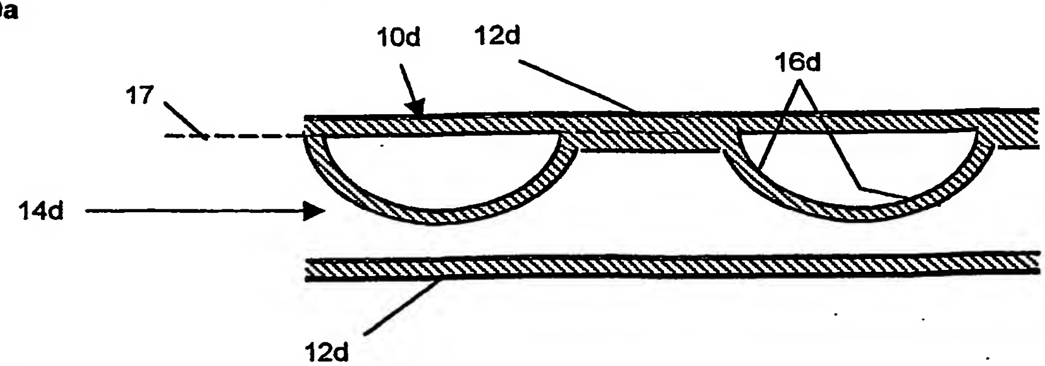

FIGURE 10b

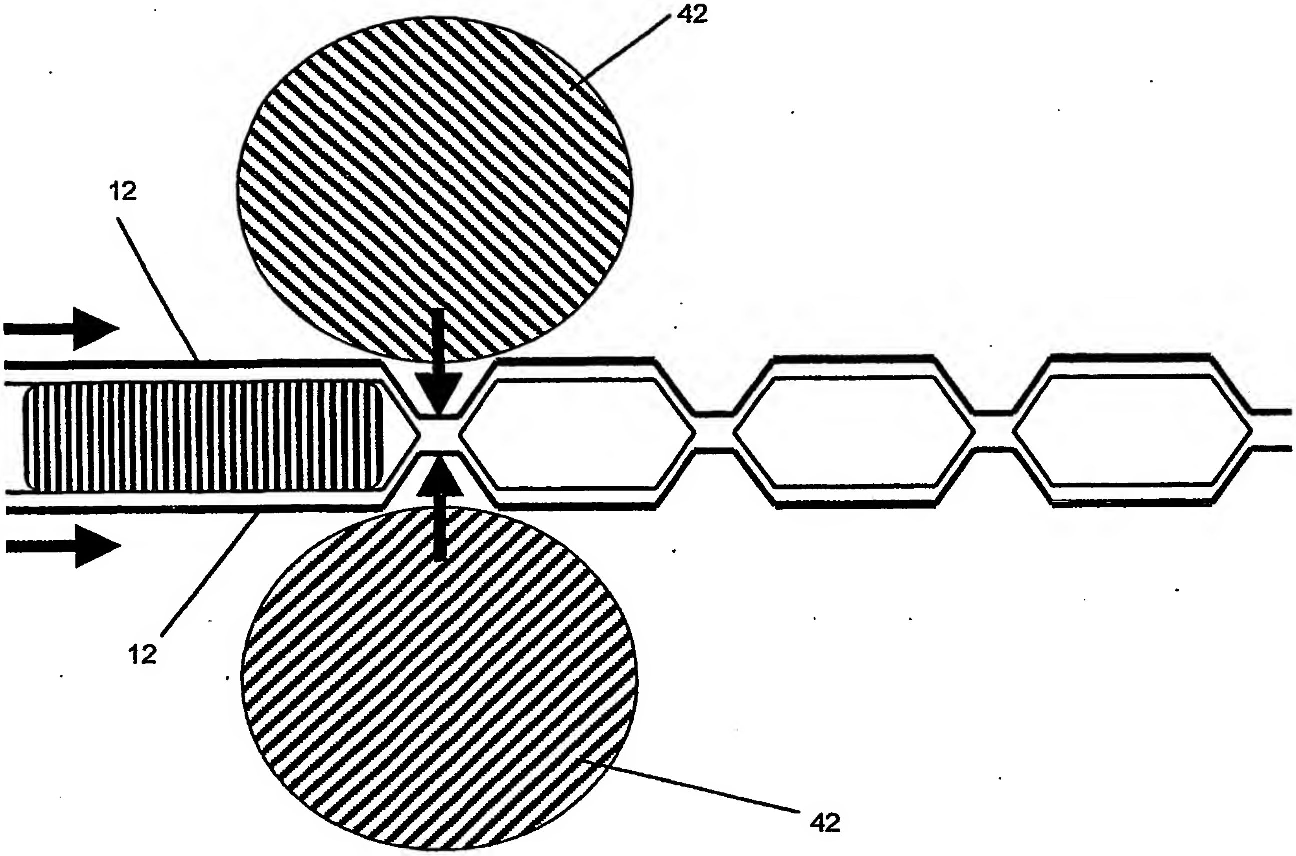

Figure 11a

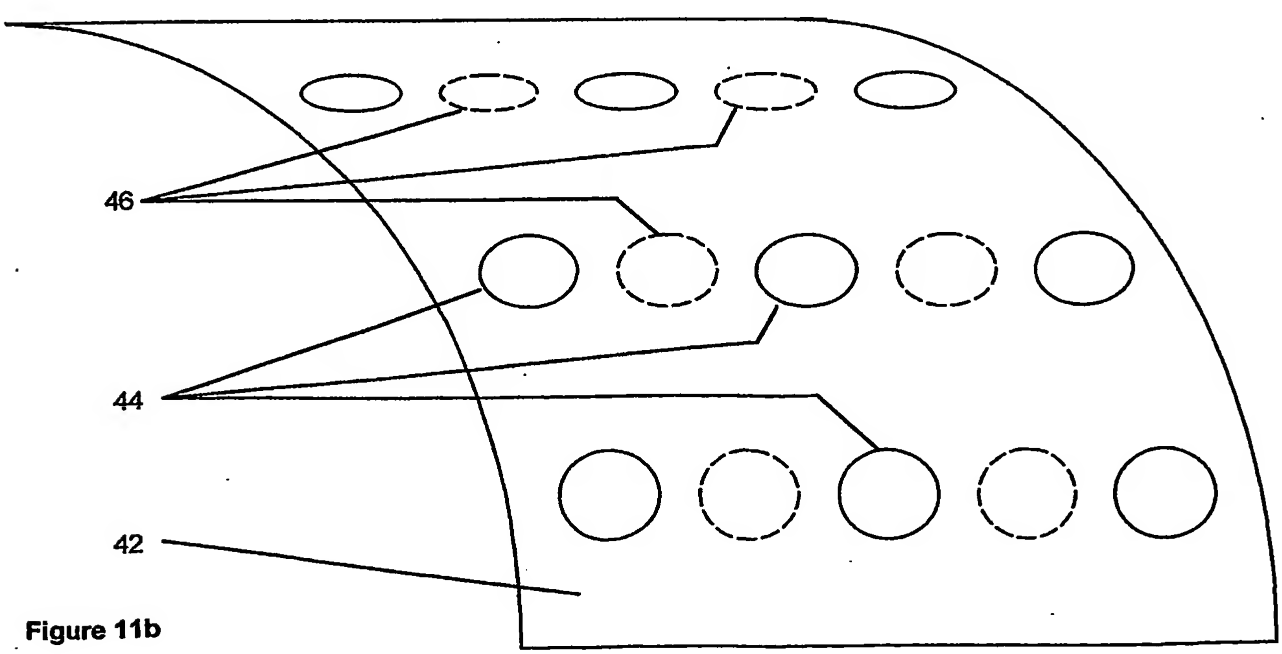

Figure 11b

PCT/GB2004/004825